Hall A SoLID Solenoid PLC Controls for CCR LN$_2$ Valves

Pablo Campero & Mary Ann Antoniloi
and the Detector Support Group
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Contents

• Overview
• Valve control modes
• Remote mode
• HMI screens to control and monitor valves
• Conclusion
Controls Overview

PLC Controller
PLC DI Mod
PLC Relay mod
PLC ADC mod

Conductor Rack

Local/Remote Control Key Switch

Instrumentation Rack

Motor Controller Relay Board

Macro Sensor LVDT module

Valve

24 VDC

MCR Board

Detailed connections diagram is available at Motor Controller Relay Board talk
Valve Control Modes

• Joule Thomson Valves (JTV) can be controlled either locally or remotely
• A keyed switch installed in valve panel at instrumentation rack controls operation mode
• Remote mode is performed by the PLC

Operations
JTV1–JTV7, JTV9–JTV10, EBV8

Remote mode
JTV1–JTV7, JTV9–JTV10, EBV8

Local mode
JTV1–JTV7, JTV9–JTV10, EBV8
(3-pos. switch)

Manual mode
JTV1–JTV7, JTV9–JTV10, EBV8
(HMI screen input)

Automatic mode
JTV1–JTV7, JTV9–JTV10, EBV8

PID controller output
JTV1–JTV2, JTV4–JTV7, JTV9–JTV10

Valve setup
JTV1–JTV7, JTV9–JTV10, EBV8
(HMI screen input)

M. A. Antonioli
7/21/21
Valve Control Modes – Cont.

• **Local control**
  – Local LVDT voltage readout
  – Fully open and close valve with the manual three-position switch
  – Monitor local or remote status by viewing switch
  – Check relay status by viewing MCR board LEDs
Valve Control Modes – Cont.

• Remote PLC controls
  – Valve position
    ▪ readout (LVDT in %)
    ▪ control—fully close or open valve, or set position (operator input mode)
    ▪ control using PID algorithm (only in automatic mode)
  – Alarms when valve positioning errors are present
  – Data archiving of valve position
  – Automatic control of valves while cooling down or warming up magnet
Valve Control Modes – Cont.

- **Remote PLC controls**
  - Interlocks to protect the magnet
  - Real time monitoring via HMI screens
  - Monitoring of local/remote control mode status
  - Monitoring of relay status associated with valve motor drive for each valve
Remote Mode

PLC controls JTVs in two remote modes: **Automatic and Manual**; user selects mode from HMI screen

- **Automatic Mode**
  - Valve setpoint is selected automatically by the PLC based on cryogenic and cooldown conditions
  - Valve setpoint to open or close valve can be determined by
    - **PID control**: Output value of the PLC PID instruction controls the set value for the valve position
      - Parameters for PID are entered on *Valve Setup* HMI screen
    - **Setting up values**: Values entered by operator on *Valve Setup* HMI screen to set valve position
Remote Mode (Cont.)

• **Manual Mode**
  – JT valve setpoint is determined by user-entered value within of maximum and minimum limits
  – Valve position is determined by values entered on *Valve Page* HMI screen
Remote Mode for JTV3 (Cont.)

- Flow chart shows logic to control valve’s closing and opening
- Position proportional (POSP) instruction’s output controls relay contact that is pulsed with a width proportional to difference between desired and actual position, to open or close at a defined cycle time
Remote Mode for JVT3 and JTV5 Cooldown Conditions

- Flowchart shows logic to read cooldown parameters and conditions to set Boolean PLC tags
  - cd_LN2_Shield
  - cd_LN2_level
- PLC tags determine the value to set valve aperture while it is on PLC Remote-Automatic control mode (PID output or Valve Setup HMI input values)
## PLC Controls True-False Table for JTV3 and JTV5

### Operating Mode:
- **Fill LN2 Reservoir (LN2 level)**: Fill LN2 Reservoir (LN2 level) 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0
- **Fill Magnet Shield**: Fill Magnet Shield 1 0 0 0 0 1 0 1 0 0 0 1 1

### Cryogenic Conditions:
- Cooldown
- Standby
- Stop_Cooldown
- Warmup
- Stop_LN2
- T_LN2_max<set limit?
- LN2_level>set limit?
- ~stop_LN2
- ~cd_LN2_level?
- N2_sensor_error?
- ~ (Stop_LN2 OR cd_LN2_level OR LN2_sensor_error)?
- cd_LN2_shield?

### JTV3 Setting

### JTV5 Setting

### True/False table to control LN\(_2\) valves for JTV3 and JTV5 in automatic mode

<table>
<thead>
<tr>
<th>Labels</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>~</td>
<td>Not Boolean</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>FALSE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>TRUE</td>
<td></td>
</tr>
</tbody>
</table>
Summary of JTV5 Operating Conditions in Auto Mode

In automatic mode, JTV5 valve regulates LN$_2$ flow to nitrogen reservoir in CCR (top fill valve)

Valve is open (takes PID output value to set valve aperture) while:

1. Cooldown or Stand_by operating modes are active
2. AND read temperature in magnet shield is below set limit
3. AND read LN$_2$ level > set limit
4. AND Warm_up or Stop_cooldown operating modes are not active

Otherwise, valve will be closed, taking Min. Setting value from HMI screen
Summary for JTV3 Operating Conditions in Auto Mode

- JTV3 valve regulates LN$_2$ flow to magnet shield (bottom fill valve)

- Valve is open (takes Max. Setting set value) while:
  1. Cooldown_Stop or Warm_up operations modes are not active
  2. OR JTV5 is closed (same as having cd_LN2_level bit = 0)
  3. OR there are no errors on LN$_2$ level sensors
  4. AND Cooldown or Stand_by mode are active

- Otherwise, valve will be closed, taking Min. Setting value from HMI screen
1. Overview status and monitoring of all valves
2. Clicking valve symbol opens corresponding JTV_Page HMI screen
3. Navigation to HMI screens used to control and monitor each JTV and EBV valve
1. Valve settings
2. Hall A 4 K flow limit
3. Valve PID parameters control or setpoints for process variables
4. Save and restore options
5. Liquid level status
6. The position proportional (POSP) button opens POSP screen for each valve

Valve Setup screen for setting values to control valves in automatic mode
HMI Valve Controls – Valve POSP

• Each JT valve has a screen
  – Accessed from Valve Setup screen
• Controls input parameters required for POSP instruction running in PLC controller
  1. Period of output pulse
  2. Percentage of valve to be opened per second
  3. Percentage of valve to be closed per second
  4. Maximum time that open or close pulse can be on
  5. Minimum time that open or close pulse can be on
1. Monitors valve positioning fault status
2. Readout value for valve aperture
3. Allows navigation to valve position readback trend plots
4. Allows selection of automatic or manual mode by clicking buttons
5. Monitors key switch status (local or remote)

6. **In automatic mode**
   - Values entered on max and min limits are used to set:
     - PID instruction limits
     - Entered limits for *Max Setting* and *Min Setting*

7. **In manual mode**
   - Directly controls valve position (*Set value*)
   - Max and min inputs ensures that *Set value* is within limits
Conclusions

• PLC programming and HMI screen development to control valves are mostly completed
• Documentation for valve control systems is in progress as part of the PLC Control Manual
Thank You